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RALPH W. POPE, *Secretary*,
33 CORTLANDT STREET, NEW YORK CITY.
Telephone, 2199 Cortlandt.

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Inaugural address by the President at the 147th meeting of the American Institute of Electrical Engineers, New York, October 24th, 1900.

THE PARIS EXPOSITION OF 1900.

BY CARL HERING.

A large international exhibition, like the one about to close, may be judged from two standpoints. For commercial reasons a necessary feature is its general attractiveness, that is, its beauty, architecturally as well as in the arrangement of the grounds and in the decorations, its proper combination of instruction and entertainment, and its purely entertaining features. On the other hand such an exhibition should be a representation of what is called the state of the art in the various industries, and to a certain extent at least, show the relative importance of competing industries.

From the first of these standpoints this exhibition may be said to have been a great success. It certainly was very beautiful and attractive, and in this respect it was typically French, for to the Frenchman such an exhibition would be a failure if it were not beautiful. While there were undoubtedly a few architectural features that might be criticized unfavorably, yet in general the buildings and arrangement of the grounds left little to be desired, although the absence of straight lines in the architectural decorations of the main buildings might not meet with the approval of every American, for in this respect they differed typically from those in the Chicago exhibition. The arrangements and decorations of the characteristically unsightly interiors of long exhibition buildings, were also very tasteful and effective, although the avoidance of a regular system of aisles made a systematic study of the exhibition an almost hopeless task. In some of the attractions, such as the Optical Palace, the underground mines, etc., instruction and entertainment were

combined, but as a rule the too numerous "side shows" were for amusement only, and were typically French.

From the other standpoint, that of showing the state of the arts, the exhibition may have been, and undoubtedly was, a success in many departments, but that claim can hardly be made for the electrical industry. For France, Germany, Switzerland, and a number of the other continental countries, the electrical exhibits doubtless represented the true state of the art and the best general practice as far as these countries were concerned; but the absence of a proper representation from the United States proportionate to the enormous development, made the exhibition an incomplete representation of the present state of this important industry. Any one judging its development in the respective countries by their exhibits, would have obtained a very wrong impression of its progress in the United States, or of the general practice here. We sent over a few excellent electrical exhibits, and they were greatly admired, but there was general disappointment that a country in which the electrical industry is known to be so largely developed, was so inadequately represented. This is all the more unfortunate at the present time when our export trade of manufactured articles is growing so rapidly, and when our electrical practice, in certain directions at least, is thought so well of by foreigners that many of them come over here to study it.

The fact that several of our largest manufacturers have ceded their rights in foreign countries to local companies and therefore claimed to have no interests there, may explain in part the absence of some of the important American electrical exhibits. But unfortunately these local companies do not always follow our practice, and do not manufacture the goods on the same scale and in the same way, so that their exhibits were not as a rule representative of our products.

England also was very inadequately represented in the electrical classes. The English claimed that they were tired of exhibitions, but another reason is no doubt the unfortunate political relation with France. England's exhibits in other groups also seemed to fail to represent the proper magnitude of the respective industries in that country.

Of all of those foreign to France, Germany, its former bitter enemy, had by far the finest exhibits in most of the groups, including the electrical. Another feature of interest politically, is

that Hungary had in many respects better exhibits than its stepmother country, Austria, and was represented as an independent nation; it bids fair to become one of the greater industrial countries of the east.

The question is frequently asked how the Paris exposition compared with the one in Chicago in 1893. As both were very large and creditable, a comparison becomes difficult and in order to give an opinion of any value one ought to have studied both equally thoroughly, and under equally favorable conditions. It is also largely a matter of individual taste, and depends on the nationality of the one giving it, as also on the extent of his knowledge of French. The area of the Paris exhibition was 336 acres, which together with the annex made it about half as large in area as the fair in Chicago which had about 1000 acres. The average number of paid admissions seems to have been about double in Paris, due to the fact that it was so managed financially that the average admission was about seven to ten cents as compared with somewhat less than fifty cents at Chicago. Americans seem to have obtained their unfavorable views from antagonistic English papers.

It is thought safe to say that the Paris exhibition, taken as a whole, was more generally beautiful in details, but that it contained no single group as magnificent as the famous Court of Honor, nor were the illumination effects as fine as at Chicago, where they were electrical, while in Paris gas was largely used. the whole of the largest open area, the Champ de Mars, being a brilliant mass of incandescent gas lamps. Neither had as finely illuminated fountains as the exhibition of 1889 in Paris, although the background to the poorly illuminated fountains in the present exhibition, forming the famous Chateau d' Eau or Water Castle, was very beautiful and attractive.

The means of getting to and from the exhibition were very poor, as Paris has unquestionably the worst managed tramway and 'bus system of any large city in the world; its cab system, the best and cheapest of any large city except perhaps London, was of course entirely inadequate and too expensive, for the exhibition traffic. The exhibition however had the great advantage of being practically in the city itself, and in one which is admitted to be the most beautiful in the world, offering many attractions to visitors, and containing treasures which make it in itself an exhibition worth going to see. The Paris exhibition

was decidedly more truly international than the one in Chicago, and the social intercourse of those officially connected with it was for this as well as for other reasons, including the generous hospitality of the French, more interesting.

The electrical exhibit was greater in Chicago, where it filled a large separate building, while in Paris it was confined to a moderately small part of one of the buildings.

Among the classes of exhibits of well-developed industries, there were three in particular which may be mentioned here specifically, as each marks a distinct and important direction of development, and was exhibited for the first time very prominently at a large international exhibition. They are the automobile, the incandescent gas lamp, (known here as the Welsbach,) and the three-phase generators, motors and systems. The automobile exhibit was very large, but unfortunately for the electrical industry, it seems that the gasoline vehicle is gaining very fast in the race with the electric. In Paris where automobiles are being used quite extensively, the quiet but heavy electric vehicle is seen only occasionally, while the light but noisy and malodorous one using gasoline, is heard and smelt very frequently. The incandescent gas lamp was used in large numbers on the Champ de Mars, the only large open area in the exhibition, where arc lights would otherwise have been installed. Even the friends of the electric light must admit that the illumination produced by it was very effective, brilliant and white without being dazzling. This lamp is getting to be a very serious competitor to the electric light, and some of the European central stations, particularly in the home of its birth, Austria-Hungary, are having serious difficulty in competing with it. The third of these prominent classes of exhibits, the three-phase machinery, will be referred to below.

Another feature of indirect interest to the electricians is that most of the acetylene illumination was relegated by the authorities to two small strips of land unoccupied by any buildings, along the banks of the river, which seems to indicate that acetylene illumination is limited to a narrow field of its own.

Much else might be said about the exhibition in general, but we as electrical engineers, are more interested in the electrical exhibits. As was already mentioned above, these were representative of the state of the art only as far as the continental countries were concerned, as those from the United States and England were very deficient in scope. It was also stated above

that it was less of an electrical exhibition than the one at Chicago. There were moreover no quite novel, epoch-making electrical inventions shown, although a few quite interesting ones that were already known to readers of the electrical journals, were exhibited there for the first time. Detailed descriptions of all the important apparatus have doubtless been or will be given, in the electrical journals where they more properly belong and where they can be read at one's leisure, and therefore no attempt will be made here to give such descriptions, even if time permitted, the intention being merely to mention some of the chief features and to make some general observations.

One of the striking features was the great prominence of three-phase generators, and their size. One obtains the impression that the three-phase current has triumphed over all the others, including the continuous current, when large amounts of power are concerned, and that it would be poor practice now to install large units of any but the three-phase system unless one is forced to use another. There was shown a decided tendency toward the use of large units, and quite a number were exhibited having outputs of about 1,000 kilowatts and over. The greater number were for three-phase currents and all formed the fly-wheel of their direct-connected slow-speed engines, while all of the few large continuous current machines exhibited, had to have a separate fly-wheel. That the field is made the revolving part seems to be almost universal practice, as also the distributed winding on the armature. Single and two-phase alternators and large continuous current machines were the exception.

Two very ingenious attempts were shown to compound large, three-phase generators, without commutating the main current, one by Hutin and Leblanc and the other by Boucherot. Both excite their direct current and mechanically coupled exciter, by means of the three-phase alternating current, the exciter therefore having a revolving field but fixed brushes; in both, the excitation of the exciter is dependent on the voltage of the alternator and on the main current, in the former by means of a shunt and series field magnet coil, and in the latter by means of a transformer combining the effects of both. To obtain direct current from such an exciter the connections between the commutator and the coils in the former are reversed according to a certain law, while in the latter the armature has several windings differing in their number of turns according to a sine law. Both

claim to keep the voltage of the generator constant for different currents and load factors. It will be noticed that there is no commutation except that of the small exciting current in the direct current exciter. Whether they are better or worse than the commutating systems used here, practice alone can decide. While they are interesting studies, it does not yet seem to be proved that for large units at least, a cheaper attendant than these would require, with his hand on the rheostat and his eyes on the voltmeter, is not a more practical solution.

The amortisseur of Hutin and Leblanc, consisting of a short-circuited cage through the poles of the magnets, for facilitating parallel running, seems to be meeting with some favor and is being commented upon very favorably.

The largest generator exhibited was a 72-pole, 3,000 K. W. three phase machine, of the Allgemeine Elektricitaets Gesellschaft of Berlin. Its speed was 83, frequency 100, voltage 6,000, weight about 160 tons, and diameter of revolving field about 24 ft. As many as 21 of these are under construction. It was claimed to be the largest in the world, but this is an error, as generators of 4,000 K. W. and over are in use in this country at even slower speeds. Several others above 1,000 K. W. were shown, the slowest speed being 72, of the 2700 K. W. mixed single and three-phase current Helios machine.

The direct generated voltages of the three-phase machines was from 2,000 to 6,000 volts; there was one exhibit of a comparatively small generator for 30,000 volts, but as long as good transformers can be bought, such excessively high voltage machines will probably be used only for exhibitions and laboratories.

There were a number of inductor alternators exhibited, which indicates that they are meeting with some favor.

Connecting lamp circuits to three-phase generators does not seem to be considered a sufficiently serious matter to overbalance the advantages of that system. The method used by the General Electric Co. of Berlin (that is, the Allgemeine Elektricitaets Gesellschaft, which even in Germany is generally abbreviated to A. E. G.) is simply to distribute the lights as evenly as possible over the three branches. All three mains are run into the buildings of even small consumers, although only two may be used, the third being available for changing over a batch of lamps, if necessary, for balancing. The voltage can thus be regulated only for all three branches together, and not for each sep-

arately; but this is not considered a serious disadvantage. The Oerlikon Co. on the other hand, connects lamp circuits between the ends of only two of the three branches of a star-connected winding, the third branch being then idle; this enables the voltage of that single-phase alternating current circuit to be regulated at the machine. By overloading these two circuits 15%, the capacity of the generator is about the same as for motor circuits with a power factor of 0.8. The units in a station can then be alike, and it does not interfere with paralleling, or running motors and lights from the same machine if necessary. Another method used in Switzerland but only with two-phase generators, is to construct a sort of double machine, the two halves of which may be mechanically displaced relatively to each other to generate two-phase currents for power purposes, or they may be connected in line with each other to generate single-phase currents for lighting.

The high voltage, direct current series system for power transmission and very limited distribution, made another and probably unsuccessful appeal for recognition, in the form of an exhibit by its indefatigable champion, Mr. Thury.

The large engines exhibited were as a rule slow speed, which is the prevailing practice on the continent. The very high speed steam turbines are also meeting with favor.

Among the various types of motors, the most interesting was the three-phase induction or Tesla type, which seems now to have demonstrated its superiority over all the others except perhaps the continuous current motor, upon whose field it is however encroaching very decidedly, with the present prospect of becoming its equal in importance. The largest company in Germany and perhaps in the world, estimates that its sale of three-phase induction motors will before long exceed that of its continuous current motors. Its very large factory, including even the rolling mill, is equipped with these induction motors mostly direct connected. There is a single textile factory in Switzerland in which 500 of these motors are used for direct driving. The induction motors, almost exclusively of the three-phase and not two-phase type, are being introduced very largely now, especially in Germany and Switzerland.

A nearly uniform type seems to have been adopted by most of the makers. In this, the primary circuit is the stationary one, and is distributed over the surface like a drum winding, as distinguished from the coils used in the earlier forms of Tesla.

It is this distributed winding which is the chief improvement that has made them such a success; it seems to have been first introduced by Dobrowolsky in Berlin. The larger ones are almost always started with a resistance in the secondary external to the motor; in some cases a short-circuiting device is provided on the rotor for use after starting, so that the brushes may be raised while running, to prevent wear. It will be noticed that in some respects this nearly universal practice abroad differs from that in this country where even very large motors up to 800 H. P. if not more, are made without any brushes, being started with a transformed current at lower voltage: others are made with the starting resistances on the rotor itself, which also dispenses with brushes.

Among the few other devices exhibited for starting such motors, the object of all of which is the avoidance of slide rings, may be mentioned the ingenious one of Fischer-Hinnen, who uses an inductive resistance of very low ohmic resistance, in parallel with a non-inductive one of high ohmic resistance; together they act like a high ohmic resistance when the motor starts, owing to the high frequency of the secondary currents, and diminish automatically as the motor increases in speed, because the frequency of the secondary then diminishes; they are permanently connected to the rotor. In the Deri motor the number of poles is changed by a switch in the primary, and the resistances are permanently connected between points of the secondary which have a difference of potential for one number of poles, but are of the same potential for a different number of poles; they are therefore either in or out of circuit and admit of no gradation, which is a disadvantage. Boucherot uses practically a double motor, the field of one of which, may be mechanically turned through a certain angle for starting; the two secondaries are permanently short-circuited in series with each other, but have resistances connected between the coils through which the secondary current is forced to pass when one of the fields is displaced, but only then; it seems like a rather complicated device as compared with the simpler slide rings which it replaces.

For the A. E. G. induction motors, Dobrowolsky claims that they will stand a 200% overload, have a power factor of over 0.9 and still give the normal output for two thirds the normal voltage.

Induction motors are built on the continent for high voltages

up to 6,000 and I believe even 10,000, thus saving the transformers for all but higher voltages than these.

As to single-phase induction or non-synchronous motors, it looked as though most of their makers thought it best not to exhibit them, or to evade questions asked about them. Among the exceptions may be mentioned the Brown and the Oerlikon motors both of which start with an auxiliary winding. Brown, who constructs them up to 100 H. P., states that they start with $\frac{1}{4}$ to $\frac{1}{3}$ full load torque at about normal full load current. He has even made them for starting with full load torque at about double normal current. The air gaps are very small, from 1 to $1\frac{1}{2}$ m. m. A cheap liquid condenser made of iron plates in soda solution, is used for producing the artificial starting phase. The Oerlikon motors are claimed to start with $\frac{1}{4}$ normal torque requiring 80% normal current, and to stand an overload of 50%. An impedance coil is used for starting.

A very interesting installation of single-phase motors, and quite a unique one, exists in Frankfort o. M., Germany, where about 500 such motors, mostly by Brown, are connected to the large single-phase alternating current plant, the motor load of which has leveled the load curve very decidedly. They vary in size up to 100 H. P. and are used even for elevator work. They appear to be satisfactory to the users, even though they must always be started unloaded. This is probably the largest motor plant of its kind and shows what can be done even with single-phase motors.

One of the applications of three-phase induction motors which is of special interest, and which seems to have a promising future, is to traction. This three-phase traction system, which is scarcely known in this country, is in regular and apparently very successful use on a number of lines in Switzerland, where it is being introduced by such well known constructors as Brown, Boveri & Co., and the Oerlikon Co. A few of these roads were visited by the writer and as far as could be learned they were running very satisfactorily. The double trolley wire, which is essential, and which has often been urged as being such a serious objection, does not seem to give any trouble at all; each locomotive or car had even two contacts with each wire. Many of the alleged objections are overcome by the use of the contact bar instead of the trolley wheel, which completely avoids any jumping off of the pole, and greatly simplifies the overhead wiring at the

switches, which is in fact not complicated at all. The motors are started with resistances in the secondary as usual. There is no complicated controller, as the two motors are always in parallel. The trains start well and without difficulty, and it seems, without any very abnormal current. The chief objection to the system seems to be that the running speed is always the same, in which respect it is like a cable road; it is therefore not possible to make up lost time except on a down hill coast, while on steep up grades there is a considerable demand for power as the speed is always the same maximum. No system of efficient speed regulation is used, presumably because none has been found to be satisfactory. This seems to be the real and serious objection to the use of the system in this country, where high speed seems to be an essential requirement. One of the freight locomotives was provided with a purely mechanical device for halving the normal speed, but no other information could be obtained than that it was then in the repair shop.

On that bold enterprise, the Jungfrau Bahn, which will ascend one of the highest snow peaks in Europe, a very ingenious and apparently novel device is used on one of the Oerlikon three phase locomotives, in order to enable a train to descend to a habitable region even if connection with the power house is broken or if something should happen to the trolley wires or poles. Ordinarily in descending, the induction motors act as generators, sending their current back into the line, which therefore must be intact. The device referred to, consists of a small direct current generator driven by the descending locomotive, the current from which is led into one branch of the star or Y-connected primary and out at the other two ends in multiple; this excites the motor and it then generates alternating currents in the secondary which are dissipated in the resistances used for starting; it thus operates as an electric brake without being in contact with the line.

While three phase traction in its present state would probably not be practicable here for cities, there seems to be a field for it on long distance interurban lines with few stops, as it is much cheaper. The estimates for the Jungfrau Bahn showed that the first cost would have been 50% greater if the continuous current had been used on the locomotives, as is done in this country.

Returning to the subject of alternating current generators and motors in general, there is a characteristic difference between

European practice and that in this country which seems worth mentioning. Here the coils are usually form-wound and then laid into open slots; there the wires are more generally threaded through completely closed holes as in the Oerlikon and Brown machines, or through holes of which the webs have been cut through with a very thin saw cut, as in the Dobrowolsky machines of the A. E. G. Mr. Brown gives the following reasons for his preference: lower magnetic resistance, smooth surface of core, seamless tube insulation, solid poles, ease in parallel running and avoidance of wedges, binding wire, etc.; his experience is that it takes as long to replace a form-wound coil as to thread in a new one in place. Dr. Behn-Eschenburg, the engineer of the Oerlikon company, gives his reasons as follows: The smoothness of the surfaces enables the air gap to be made as small as 0.001 of the diameter in induction motors, which is hardly possible with teeth; with a web over the hole of only 0.1 m. m. the coefficient of magnetic straying can be reduced to 0.04 and a maximum power factor as high as 0.92 can be obtained; the maximum torque will correspond with 3.5 times normal current, and the possible overload can be 2.5 times the normal; if the holes were changed into teeth, all else remaining the same, the magnetization current would be at least doubled, the straying coefficient reduced to about 0.03, and the best current for the resulting maximum power factor of 0.94 would then be more than doubled and the copper conductors therefore increased, or for the same load the power factor reduced to 0.91; the slotted armature would have to be made longer axially if it is to have the same current at no load as the one with holes; moreover, seamless insulation tubes of micanite can be used in the holes, which if 1 m. m. thick will be quite safe for 3,000 volts. However he quite impartially recognizes the favorable features of slots with form-wound coils and admits that they may outweigh the others if a factory is suitably equipped for such work; he believes that under certain circumstances the one, and under others the other, is the better.

Another interesting characteristic difference between American and continental practice, is that here synchronous converters combined with transformers are more generally used for transforming high voltage three-phase currents into low voltage direct currents, while on the continent dynamos driven by high voltage induction or synchronous motors are the rule. Although the fa-

vorable features of each are well understood, the reasons given by such a successful constructor as Brown for preferring motor-generators, may nevertheless be of interest here. He states that: they can be regulated with ease and precision; no transformers; both parts can be better designed without making concessions; no hunting; ease in starting; no depolarization possible; secondary voltage absolutely independent of the primary. He admits that the synchronous converter is cheaper and more efficient, but claims that the differences are but slight; he has obtained 90% combined efficiency for a 250 K. W. motor-generator set.

The difficulty of not being able to regulate the voltage of a synchronous converter, is overcome by Dobrowolsky in a very ingenious and apparently successful way. Instead of passing the continuous current through a booster, which would require an expensive machine, and generally with a very large commutator, he passes the alternating current through an alternating current booster on the same shaft; this is separately excited with a continuous current and therefore permits of regulation. The one shown to me would raise or lower the voltage 25% making a range of adjustment of 50%. It either drives or is driven by the converter. Although this overcomes one of the chief objections to synchronous converters, he has not changed his preference for motor-generators.

Another modification of interest used by this same engineer and others, is that six-phase instead of three-phase currents are led into the synchronous converter, the advantage being that its output is thereby increased, according to a French constructor about 45%. The attending disadvantage of six slide rings instead of three, is said to be more than balanced. The general use of three core transformers, for three-phase currents instead of a single one for each phase, as is customary here, is another instance of a difference in practice.

It was of some interest to note the almost complete disappearance of the Gramme ring armature among generators and motors, and the use of multipolar fields for smaller sizes than formerly, especially with motors. The Dobrowolsky system, hardly known here, of supplying three wire circuits from a single generator, by connecting the neutral through induction coils and slide rings to two opposite parts of the armature winding, seems to be meeting with favor on the continent.

A criticism of American motors made by a prominent German

manufacturer who has bought and tested many, was that an American horse-power was only three-quarters of a real horse-power.

In electric railroading there seemed to be comparatively little of special interest to Americans, besides the three-phase motor system and the contact bar, already referred to, both of which deserve more attention here than they are getting. The new Metropolitan underground electric road quite recently opened in Paris, is apparently an excellently constructed but wretchedly managed road. American management would diminish the total time of transit and increase the profits greatly. It is an improvement over the new underground road in London in that motor cars are used instead of locomotives, but being directly under the street instead of very deep, as in London, the excellent device of a descending and an ascending grade between stations, to aid acceleration and stopping, cannot be taken advantage of. Both of these roads use American electrical machinery.

The two new electrically operated extensions of several steam railroads into the central parts of Paris; the new and much needed electric railroad to Versailles; and the new conduit road in Paris, are all of interest. A surface contact line and one using accumulators, are also being tried in Paris. The Western Railroad, one of the largest steam railroads of France, is making very extensive preparations toward introducing electric traction on its lines by more improved methods than its Heilman locomotives. If our steam railroads were as enterprising, the replacing of steam by electric traction would progress more rapidly here. Through the kindness of Mr. Clerault, the chief engigineer of this enterprising steam railroad, our INSTITUTE had the pleasure of accepting an invitation for a personally conducted visit to its interesting plant. It has already in operation in part, a large three-phase power station near Paris, accompanied by extensive laboratories; has constructed an electrical extension of its steam lines toward the center of the city; is building the new electric line to Versailles over an excellently constructed and well graded private roadway, and has under construction a number of electric locomotives. Paris is therefore at last beginning to avail herself of the advantages of electricity for traction, and will unquestionably be very greatly benefited thereby. If with this modern traction force, a more modern and more American system of managing and operating the city tramways were intro-

duced, the Parisians, the many visitors and the owners of the tramways, would all be the gainers.

In the exhibition itself may be mentioned the two miles of moving platform which differed from the one in Chicago in that the motors were stationary while the rails moved. The third rail electric railroad paralleling it but running in the opposite direction, was virtually an American exhibit and was managed more like American roads, making a refreshing contrast to the wretchedly managed tramways and omnibuses in the city. Both the platform and this railway were fed from two 800 H. P. induction motor-generator sets made in this country, the induction motor, started by its mate, being one of the largest ever made. The conduit road which was shown, was also virtually one of those developed in this country. A short section of the "suspended" railway was exhibited, but whether this struggle for recognition was successful seems questionable. Another curious departure shown in operation was the trolley automotor, a system of running electrically driven vehicles on ordinary roads, but taking current from an overhead trolley wire. The novel feature was that the small contact carriage running on the two wires, was geared electrically to the motors by means of a local three-phase current, so that it tended to travel slightly faster, thereby always leading and keeping the connecting cable taut. A field for it might exist where omnibuses are now used.

A number of large electric locomotives were exhibited, notably one from Berlin, showing that heavy electric traction is making progress. One weighing about 45 tons exhibited by the French steam railroad known as the P. L. M., was operated with accumulators carried on a tender, but the claims made for it by the attendant were so remarkable that a verification is desirable before they can be considered. Although it was dated 1896, I was told that it was "not yet" in constant use.

In electric lighting, one of the most interesting features was the debut of the Nernst lamp. After long and tedious labors on the part of the General Electric Co., of Berlin, the interesting laboratory experiment of Nernst, that a filament of a non-conductor like magnesia becomes a conductor after it is heated,—has been developed into a form of high efficiency incandescent lamp, which is now claimed to be ready for the market; but although several hundred were burning there daily it was not possible to buy one. It resembles the usual incandescent lamp except that

the bulb is open; the filament is somewhat thicker and much shorter than that of a carbon lamp; the light is very much whiter and more brilliant. It can be lighted with a match, alcohol torch or automatically by a platinum wire preheater with a magnetic interrupter. Either alternating or continuous currents can be used but the filament must be exposed to the air. The lamps are made for 25, 50 and 100 C. P. at 220 volts, and therefore do not yet compete directly with the usual 16 C. P. lamp. The efficiency is said to be 1.5 watts per candle, or about twice as good as the present carbon lamp of the same voltage. The filament is said to be made of magnesia mixed with the rare earths like zircon, thorium, etc. The life is claimed to be very satisfactory, though no figures could be obtained, but the perishishable parts, valued at only 25 per cent. of the probable cost of the lamp, can easily be replaced, the bulb being open.

The material of which the filament is made, has a rapidly falling temperature coefficient, much worse than carbon, which would make it extremely sensitive to changes in voltage. This is overcome by a very ingenious method to which the present success of the lamp is due; it consists in placing a very fine iron wire in series with the filament, the wire being so proportioned that it is heated by the normal current to that temperature (about 450 to 500 degrees C) at which it has a very rapidly rising temperature coefficient; the resulting characteristic of the two in series is therefore a rising one. This fine wire consumes about 10 per cent. of the voltage. The price of the lamp, it is thought, may be about 50 cents.

Among the novelties in arc lamps which attracted some attention during the few days it was on exhibition, was the Bremer lamp in which the carbons contain certain salts, like those of magnesia, together with fluor calcium, that deposits a white oxide on surrounding bodies which acts both as a Nernst conductor and a white reflector, the carbons being inclined like the letter V. A reliable German authority found the efficiency to be 0.13 watts per hemispherical candle power. The light is said to be steady and bright but soft.

The only enclosed arc lamps exhibited were from this country, directly or indirectly. These lamps, which are so largely adopted here, are scarcely known on the continent, and in France at least, it seems that they are not even wanted, on the ground that the light is too blue and unsteady, and the efficiency too

low. As manual labor is much cheaper there than here, and arc lamps are not used nearly as much, the chief advantage of this lamp is not appreciated, at least not yet. The arc lights there are, as a rule, much steadier, and are almost universally connected to constant potential circuits, our series system being almost unknown. The general type of regulating mechanism which is in favor, is that in which the coil applies a brake to an escapement wheel which tends to revolve by the weight of the descending carbon; the regulation is therefore very sensitive and gradual. Cored carbons of a fine quality are moreover almost universally used. Generally only two lamps are in series across the usual 110-volt mains, but in some cases as many as three are connected with an increase in light efficiency; in such cases the lamps are of the differential type in which the regulating mechanism is actuated not only by a shunt coil but also by one in series.

The exhibits of electric chandeliers and like fixtures were mostly French, and were generally very tasteful, artistic and often very beautiful, although frequently marred by external wiring, as with many of them concealed wiring is impractical. The accessories, on the other hand, such as circuit breakers, small switches, lamp sockets, motor starting resistances, etc., were frequently quite bad or too complicated, from an American standpoint. There would seem to be quite a market abroad for the better classes of American goods of this kind. It is hard to understand why electrically started fires are not more frequent on the continent with such poor appliances of this kind that one finds in use there.

The relatively large number of exhibits of switchboard switches for breaking currents of very high voltage, indicates the rapid introduction of high tension currents. In many of them the well-known double horn is used for extinguishing the arc, which is an indication of the effectiveness of this simple device.

A novel departure in switchboards, especially for dangerously high voltage machines, consisted in placing all the switching apparatus belonging to one machine, on or under a post or pedestal near the machine itself, and so that the attendant faces the machine. The actual switches are under the floor where they are out of the way and easily accessible from a pit below, only the levers, hand wheels and instruments being on the pedestal; the attendant is thereby protected from all the possible danger. It is the standard practice of the Oerlikon Co.

The use of silver fuse wire in place of lead alloys, by a very large German company, on the ground of greater reliability and constancy, deserves mention. For the same fusing current the amount of metal volatilized is the least for silver.

The non-interchangeable fuses of Siemens and Halske were of some interest and seem to supply a need.

Among the cable exhibits there were three for underground work in which multiple cored cables were subjected to 25,000 and 30,000 volts alternating, the insulation in one of these being impregnated paper without any rubber.

A German maker of aluminium goods showed that this metal can be welded without solder or flux by simply heating it to a certain definite temperature at which it softens. The use of aluminium line wires makes this simple method of interest to electrical engineers.

The number of different types of meters exhibited was about equal to the number of their exhibitors, but the Thomson meter in nearly the same form as made in this country, is the one most frequently used; several hundred a day are claimed to be made by the French company which manufactures them. The field for a good, cheap and simple ampere-hour meter for small consumers of continuous current, is filled very satisfactorily in France by the O'Keenan meter, of which 11,000 are already installed. In principle it may be said to be like a d'Arsonval galvanometer or Weston instrument, in which however the coil is mounted so that it may revolve continuously, the number of its revolutions being registered. This coil or armature is a shunt to a very low resistance in the main circuit. It is extremely sensitive and the coil requires only 0.6 microwatt to start it; it will register as little as 5 watts in the lamp circuit or 1% of its range, has a straight line characteristic and is not appreciably affected by temperature changes. A somewhat similar one is about to be introduced in this country and there is no doubt a large field for it.

The well-known and ingenious Aron double pendulum meter was well exhibited in various forms, including one for three-phase currents. It is said to be used to some extent in Germany but would probably not find much favor in this country.

An interesting and promising modification in the Thomson type of watt-hour meter, shown in the German section, consisted in using a three coil armature like that in the original Thomson-Houston arc light machines; this enables the same magnetic

force to be produced by a much smaller weight of the revolving part, with several attending advantages of importance.

Prepayment meters are meeting with some favor and there might also be a field for them in this country among small consumers.

In telegraphy the exhibit which seemed to attract most attention was the very ingenious printing telegraph system of Professor Henry A. Rowland, of Baltimore. The sender merely presses lettered keys like on a typewriter, and at the other end the message is received in print on a sheet of paper ready for delivery, without requiring any operator. An alternating current of constant frequency is passed over the single line and operates synchronous motors, by means of which the necessary synchronism at the two stations is obtained. The different characters are transmitted by the suppressing of various combinations of the half waves of the current. At the receiver end those waves are received in a large number of relays, various combinations of which operate a few electromagnets for printing the characters and moving the paper laterally and lengthwise. The typewheel revolves continuously and the paper directly beneath it, is struck from below at the exact moment when the desired letter is over the paper. Four messages are sent at the same time in one direction, the line being loaned to each operator in succession for short recurring periods. This is then also duplexed, making eight messages simultaneously over one wire, each, it is claimed, at a speed of 45 words per minute. It does not seem to be used commercially yet, and whether it will be equal to or better than the printing telegraph system which has been in satisfactory commercial use between New York and Chicago for some time, devised by one of our members, can be determined only by equally severe tests.

There were several exhibits of the wireless telegraph system, though none by Marconi's company. The modifications were only in details and did not include any way of making the system selective. It is now being introduced commercially and there are a number of installations in regular use.

The telegraphone was one of the very few entirely novel inventions of promising value exhibited. This extremely ingenious and very interesting invention of Poulsen, a Dane, has been so thoroughly described in the journals that a mere mention will suffice here. It may be said to be a magnetic phonograph in

which a long hardened steel wire is passed rapidly near the magnet of a telephone receiver, the magnetic variations of which are thereby recorded on it in the form of permanent magnetism. By then passing this wire under small pieces of iron attached to a diaphragm, the same sounds are reproduced. I had the pleasure of hearing such a reproduction and can vouch for the statement that it is much clearer than from an ordinary phonograph as there is an entire absence of that objectionable scratching noise, there being no mechanical contact at all. Its suggested applications are numerous, including duplex and multiple telephony.

Those interested in the controversy between the vertical and the horizontal telephone switchboard, found a good opportunity to compare them, as each was exhibited by its most ardent defender, the vertical board being advocated by one of our large and prominent companies, and the horizontal by a similarly prominent German company which is introducing it in its country, notably in Berlin. The chief advantage claimed for the latter is that two operators sitting on opposite sides can use the same board and that therefore the length of board for the same number of subscribers is halved.

Electrochemistry was one of the electrical classes in which the most pronounced recent development was shown, although the exhibits were not sufficiently complete to show the true state of that art. This branch of electrical science has opened what promises to be one of the important fields in which there is an opportunity for great development. Products which not many years ago existed only as rare and expensive specimens, and some which were not even known, are now made electrically by the ton.

Electric furnaces were shown in operation. There was also a very fine exhibition of the extremely interesting collection of products obtained by Moissan in his classical researches. Judging from two other large exhibits, copper is successfully deposited directly in the form of mechanically strong tubes, simultaneously with the process of electrolytic refining. A single company in Germany refines electrically about 5,100 ounces of gold and 24,000 of silver a day.

A very large ozone apparatus was shown in operation, for sterilizing 200,000 cu. met. of water per 24 hours by the Marmier and Abraham process, but a confirmation of the claims made is very desirable.

The interesting process of Goldschmidt for obtaining very high temperatures of about 3,000 deg. C. by the combustion of aluminium mixed with metallic oxides was well exhibited and deserves mention, although only of indirect interest to electricians. The expense of the aluminium naturally limits its application, but this seems to be more than balanced in some cases by the other advantages. It is already in commercial use for obtaining pure metallic chromium and manganese for the iron industry, and for welding rails and tubes or mending broken iron parts.

In accumulators there was shown a general tendency, though not a universal one, to use Planté positives and Faure negatives, a combination which seems to have given the least trouble. Accumulators are now the rule and not the exception in continental lighting and traction stations. Now that the fundamental patents have run out in this country, we ought to use them more freely here. As an electrical flywheel and a comforting reserve in a central station, the accumulator has no equal.

It is impossible, of course, from mere inspection, or from catalogue data, to judge of the success of the light weight accumulator for transportable purposes, notably for the automobile. But from the awards of the jury which were based on reliable knowledge of their performance, the Fulmen, the Pulvis and the Phoenix were among the best of their kind; all three are French.

The most satisfactory development in primary batteries is that inventors—or perhaps the capitalists—seem to have at last been convinced that it is cheaper to burn coal than zinc.

A very interesting and promising method was shown in operation by its inventor, Rieder, for electrolytically engraving deep, hard steel dies, such as are used for pressing the reliefs on coins and for embossed work in general. A porous negative of plaster of Paris, saturated with chloride of ammonium, is lightly pressed against the steel blank and the metal is dissolved off electrolytically by a current, wherever the negative touches it. The cost is said to be only half that of the usual hand method.

The exhibitions of instruments were very fine, chiefly from France, England and Germany, but it would take too long to enter into a discussion of them here. That a d'Arsonval galvanometer is made with a sensitiveness of 1.2×10^{-10} amperes per m. m. deflection, is of interest; it is claimed to be the highest sensitiveness yet reached with that type of instrument. Among the station and laboratory instruments which are not generally used

in this country, but which are very convenient, are the phase meters of Dobrowolsky, indicating directly the difference in phase. A curious, but characteristically European criticism of a certain world-renowned type of American instrument, was, that "they are bad because they are expensive."

The very general introduction of micanite, an American invention for generators and motors, is of interest.

The electric plant supplying the exhibition did not seem to be a success, judging from the very numerous stoppages and the excessive variations in the voltage.

The largest number of electrical exhibits were naturally, from France. Among the foreign countries Germany was far ahead of all others in importance, and promises to become the leading manufacturing country for electrical goods in Europe, if it is not so already. One company alone employs 14,000 hands, and ranks with our largest American company. It is of interest to us, that this successful company uses American methods quite largely. The Reichsanstalt, that creditable German institution, has no doubt contributed to the rapid strides made by that country in the electrical industries, and shows what government aid can do for the industries of a country. England has already started its Electrical Standards Laboratory of the Board of Trade, a very interesting and creditable government department, which was shown to our INSTITUTE this summer during its first official visit abroad. France has its "Central Laboratory," and is considering the enlarging of its government department; Russia has a large government electrical laboratory. The United States alone, among the large countries, has practically nothing of the kind.

Switzerland follows Germany in importance. The United States and England were inadequately represented in this department for reasons already mentioned, although there were some excellent exhibits from each. The lists in the catalogues cannot be taken as a guide in such a comparison, because a simple little device of no importance has the same prominence there as a large important exhibit of several thousand horse-power of machinery. Moreover many American exhibitors who were entered in the catalogues, did not exhibit. In one class alone, the number of actual exhibitors was only 40% of that in the catalogue of the United States exhibits, and many of these were quite small. It would therefore not be just to judge the state of this industry in our country, by the exhibits or by the awards.

A characteristic difference between American and foreign practice in manufacturing, as for instance such goods as dynamos and motors, is that here the manufacturer establishes certain well studied and well developed standard types and sizes of machines once for all, and then reproduces them in large numbers, making the parts interchangeable. The foreign manufacturer, on the other hand, constructs each machine according to the detailed specifications of the one ordering it. He argues that if he should make bids with standard sizes in stock, the purchaser would accept the bid of some one else who would construct the machines exactly according to the specifications. As a matter of fact, however, it was noticeable that those companies which have adopted the American method, were as a rule the most successful. There is also a field in and around Paris at least, for American methods of managing and operating electric tramways, as existing practice is there very poor.

Another difference is that here the manufacturer as a rule devotes his whole effort to a single class of goods, and makes these in large quantities, while abroad he attempts to make a large range of widely different kinds of articles; this seems practical only when each branch is a large business in itself.

Still another difference is in the fine external finishing of even those parts of an apparatus which are concealed. Their argument is that all parts of a well made apparatus ought to look well, and that it will then be handled with greater care and respect. Here we would consider it a useless expenditure of money to polish all the concealed mechanism of arc lamps, for instance. The foreigner, however, is apt to judge our goods from his standpoint, at least until he can be convinced of their advantages.

The Jury of Awards had many delicate questions to settle, both technical and diplomatic. While mistakes are possible, it is more than likely that complaints of exhibitors can generally be traced to unworthy or inadequate exhibits, or to circumstances beyond the control of the jurors. One-half the jurors were French and in the electrical group they were very liberal and generous to the foreign exhibitors, more so than to their own countrymen. If they erred at all, it was on the side of generosity for which they deserve our thanks instead of abuse. Only two of the United States jurors for the electrical group were members of the INSTITUTE.

The Electrical Congress was an international gathering of about 1,000 engineers and scientists interested in the subject of electricity, and as a convention it was a great success, giving an opportunity of making many acquaintances and friendships among men of the same calling in widely different parts of the world. The French deserve great credit for its organization and management. A large number of papers were read, varying in quality from very good to poor, reports of which have appeared and are appearing in the journals. The social features of the visits to the neighboring electrical installations were well arranged and very enjoyable. Our INSTITUTE was represented by all of its six delegates, three of whom were elected officers of the Congress. All of the official United States delegates were members of the INSTITUTE.

As a gathering of official delegates appointed by the various governments to settle questions concerning units, this Congress came very near accomplishing nothing at all. Had it not been for the efforts of two of the United States delegates, both members of our INSTITUTE, this very important feature of the Congress might as well have been omitted. It was due to the convincing appeals of our member, Mr. C. O. Mailloux, that the chamber of delegates reversed its former decision to take no official action on units and names, and adopted without a dissenting voice the recommendations of its committee, in which our Past President, Dr. Kennelly, ably represented our INSTITUTE. These adoptions were that the name of "gauss" be given to the C. G. S. unit of magnetic intensity or flux density, and "maxwell" to the C. G. S. unit of magnetic flux. The practical units will then generally be the kilogauss and the mega-maxwell. All the other propositions of the INSTITUTE were withdrawn in committee when it was found that they could not be adopted. The only other action taken by the official delegates was a unanimous expression of opinion that electrical energy should be considered as a property to be protected by law like any other.

The reason no further official action was taken concerning names and units, as suggested by the INSTITUTE, is, in the opinion of the writer, that our propositions were new to many of the delegates, not having been discussed fully in their different countries before the meeting of the Congress. At the International Congress of 1891 at Frankfort, when our INSTITUTE endeavored through its delegates to have the names gauss and henry adopted,

the reason for the failure was the same, and in the report of our delegates[1] it was recommended that in future our propositions should first be thoroughly discussed in the societies and journals of the different countries, leaving to the Congress only the final decision on well understood propositions. Had this recommendation been followed in the present case we might have accomplished still more. Any further recommendations of the INSTITUTE should be decided upon as soon as practicable and be made the subject of international discussion in the journals and societies in preparation for the next International Congress, whenever that may be.

The first meeting which our INSTITUTE held abroad, was a memorable event and bids fair to be the beginning of a series of international meetings of electrical engineers. It brought the INSTITUTE into considerable prominence abroad, increased its influence, and afforded great pleasure to those of its members who attended. When it was first suggested by a member of Council some years ago, to hold a meeting this year in Paris, the proposition was met with some ridicule, but its success and the benefit the INSTITUTE derived from it, shows that the venture was not an unwise one, and that such meetings ought to be repeated. While we may have just pride in feeling that some branches of electrical engineering are better developed here than in other countries, and that our method of manufacturing certain classes of goods is superior, yet we should not forget that others who have worked equally hard in other countries often reach conclusions differing from ours, and which may well be worth our while to consider. Although our typically American practice of manufacturing standard types in large quantities and with interchangeable parts, undoubtedly has great advantages, yet that is the very method which tends to retard development in those types, as it makes one hesitate, perhaps too long sometimes, to make improvements. On the other hand the typically European method of building almost every machine differently, gives an excellent opportunity for developing them, but precludes wholesale manufacture at reduced cost. Such international meetings therefore can hardly fail to be of benefit to all who take part, as they enable one to find, through personal observation and personal intercourse, that which is the best the world over, just as

1. TRANS. A. I. E. E. vol. 8, p. 546.

our home meetings bring before us the best in our own country. If we want to manufacture the best there is, especially if we want the foreigner to buy it from us, we should have international intercourse.

In London, our sister society, the Institution of Electrical Engineers, entertained us with true English hospitality for three well filled days, with a most delightful program, in which pleasure and instruction were harmoniously combined. It will long be remembered by the 28 or 30 of our members who attended, as one of the most enjoyable features of the whole meeting. In Paris the official joint meeting with the British Institution, held in the National Pavilion of the United States, through the courtesy of Commissioner Peck, was well attended and was followed by receptions of both institutions, visits to objects of interest, and the Electrical Congress, making a total of two well filled weeks of international intercourse between electrical engineers, and constituting one of the most important meetings in the history of the INSTITUTE.

The success of our first meeting abroad should encourage us to follow the excellent example of the Institution of Electrical Engineers by making official visits to the different foreign countries to study their practice and examine their work. Our foreign colleagues will then be encouraged to visit our country, as many of them have promised to do next year on the occasion of the Pan-American Exhibition in Buffalo.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

Seventeenth General Meeting.

Philadelphia, May 16, 17 and 18, 1900.

The opening session of the Seventeenth General Meeting was called to order in the Drexel Institute, on Wednesday May 16, at 2 P. M., by Past-President Kennelly.

Past-President Kennelly:—The meeting will please come to order. The Secretary has an announcement to make.

The Secretary:—Most of the members present are aware that the counting of the ballots for the annual election took place last evening at New York. The number of ballots cast was unusually large, amounting to over 600. I have this memorandum from the tellers of the vote for President:

New York, May 15, 1900.

The result of the ballot for President of the American Institute of Electrical Engineers is as follows.

Carl Hering.....381

M. I. Pupin,.....179

Mr. Hering received the largest number of votes and is elected.

Signed, Townsend Wolcott and Samuel Reber, *Tellers*.

Dr. Kennelly:—Gentlemen, we have just heard that Mr. Hering has been elected President of the Institute by a majority of more than 200, and I think we may congratulate ourselves, as well as congratulate Mr. Hering upon this important announcement. I can only say I am delighted to resign in Mr. Hering's favor and it gives me very great pleasure indeed to appoint a committee to escort Mr. Hering to the Presidential chair. The committee will be Mr. Hammer and Professor Houston.

Mr. Hering, on being escorted to the chair, spoke as follows:

Gentlemen, I am very grateful to you for the honor you have conferred upon me and I hope that the officials which you have just elected will be able to conduct the affairs of the Institute to your satisfaction for the next year.

The meeting will now please come to order. The first thing on the programme will be an address by Dr. McAllister, President of the Drexel Institute, whose hospitality we are now enjoying. I take pleasure in introducing to you Dr. McAllister of the Drexel Institute.

Dr. McAllister spoke as follows:

Mr. President, and gentlemen of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS: I am very glad indeed, as President of the Drexel Institute, on behalf of the Board of Trustees to welcome you here to this meeting. I feel it to be a great honor as well as a privilege to have you with us. It is not worth my while to tell you the place which is occupied in our time by the profession of electrical engineering. I am in the habit of telling the students here that at the present hour there are two great leading professions. Those of us who were educated a generation ago or more, lived in a time when that profession hardly existed. There were the old-fashioned clerical, medical and legal professions, and that was about all. Nowadays the young man who has got the stuff in him, and the ambition, usually turns in other directions, and to my mind the two great professions to-day are the engineering profession and the architectural profession. Any one in my position knows it to be a fact—I used to talk with my friend General Walker about this—that the best young men to-day are pushing into these professions. There are many reasons for this, which of course occur to us all. Of all the engineering professions the electrical profession I think is the one which interests the mass of the people more, because it is one that is among the newest and most interesting and most marvellous applications of science to the arts of life, and has come to play a most important part in the civilization of the present, and will still more in the civilization of the future. We are very glad to have you here and I merely want to say to you that you are welcome to everything that we have. We would have liked to make some provision for your social enjoyment, but I understand through Professor Rowland, on behalf of the Committee of Arrangements, that your time will be wholly occupied in that regard. We have however, with the consent of the local committee arranged a complimentary organ recital for the members of the INSTITUTE and the ladies, on Friday afternoon at 3 o'clock, the programme of which will be distributed.

I presume most of you know very little about this institution, and entering it as you have, would be apt to get a false impression of it. I want to say to you that we think it is a fit place for an association of this kind to meet. It is an institution devoted to artistic, scientific and technical training, and is seeking in various new lines to work out the educational problem in the application of art and science to living. We have a very modern school of electrical engineering, different from the larger institutions, in some other cities, but where with a fair amount of sci-

entific training and technical training there is a larger provision for practical work in the shop; and if you will take the trouble to go behind the screen—this external part of the institution—you will find the libraries and workshops I think well equipped for the purpose. For that reason we are glad to have you here. I trust you will not regard the presence of the students who choose to come here as any intrusion.

This is all I can say, to again repeat the cordial welcome of the Board of Trustees and of the Faculty of the Drexel Institute. We trust that you will enjoy your stay in Philadelphia. We are famous—well, for a good many things, but we are famous any way for our hospitality; we can take pleasure in that; we are very proud of that, and I think you will find yourselves as cordially welcomed here as you ever have been in any other city in which you have had the pleasure to meet. I beg again to give you a cordial welcome.

THE PRESIDENT:—The Secretary has an announcement to make.

THE SECRETARY:—You will find on the platform a bundle of notices giving a bulletin from the Franklin Institute, which includes a programme of the stated meeting of the Institute this evening, May 16, at 8 o'clock, to which we have been invited.

The following programme has been arranged: "Recent Improvements in the Manufacture of Liquid Air; the separation of air into its constituent parts, and the industrial use of oxygen, nitrogen, and carbon dioxide," by Professor Raoul Pictet and Moriz Burger.

THE PRESIDENT:—In the absence of the Mayor of Philadelphia, who was to address us, we will proceed directly with the reading of the papers. The first paper on the programme is on "A New Transmission Dynamometer," by Prof. W. Elwell Goldsborough of Purdue University, who is already so well known to us through his work that he needs no further introduction.

[See p. 219, April Issue.]

Discussion.

The President:—The difficulty in such transmission dynamometers, has usually been to obtain a stationary indicator of the deflection of a rapidly revolving spring, and this seems to have been overcome in the present arrangement by a very ingenious device. The paper is open for discussion.

Mr. C. O. Mailloux:—I consider this a very ingenious, effective and practical device. Those who have had experience with transmission dynamometers know that there is very little to be said to commend the very best of them. The most satisfactory ones that I know of are the so-called Emerson type, in which the motion is transmitted through an epicyclical gear train where the torsional moment produces a lifting moment, which is used as the measure of the power transmitted. This machine, which was at one time very largely used, is however open to many objections, not the least of which is friction—the uncertain amount of friction which it has within itself. A later form of transmission dynamometer which is more satisfactory, and with which I personally have had some practical experience, is the VanWinkle dynamometer. It resembles the present dynamometer in the fact that it also measures a moment of torsion, by means of springs. It likewise gives an indication by the relative motion of two disks, which are held together by two coiled springs, the springs being arranged somewhat as in the so-called "Raffard" coupling similar to that which is used on the shaft of the Westinghouse "Kodak" dynamos. Again, however, there are difficulties, one of them being centrifugal action, which tends to throw out the springs bodily, and which causes an error in its reading by introducing additional force, namely, that of centrifugal action in addition to the strain due to the moment of torsion. In the present case the author has apparently avoided this difficulty by placing the spring on the shaft itself where it is no longer subjected to any centrifugal action; and he has also eliminated, so far as one can see, all of the losses and errors due to friction. The only thing which it seems to me the device still lacks is a means of giving a visual indication of the torsional moment; that is to say, one which would read on a scale, or one for reading which you do not have to make adjustments. The instrument in the present form will only give an indication for each particular moment, just the same as when one measures a resistance with a Wheatstone bridge set, where one has to balance for the particular value. In this case the usefulness of the apparatus is somewhat impaired by that fact, because, with fluctuating loads, or with loads which do not remain at a constantly steady value, there must be a tendency to lose the telephone tick; that is to say the torque either exceeds or falls below an amount which corresponds to the position of contact which gives the click on the telephone. Either there must be something like a dash-pot, to make the instrument less sensitive, and thereby impair its usefulness as

an instrument of precision, or else there must be means of quick adjustment, so that, when the torque varies one can still find and follow quickly the clicking spot, which is the thing by means of which the angle of displacement in the two disks is measured. It seems to me that some system of epicyclical gearing could be devised and attached to the outfit that would enable one to get a deflection indication. In the VanWinkle dynamometer a device of this kind is used, which is somewhat complicated, but it is preferable to the present method in so far as it enables one to take a large number of readings in a short time, and this is particularly desirable in the case of fluctuating loads. I should say that where the fluctuations are at all important and large, one would have considerable difficulty in getting satisfactory results with a machine of this kind. You might catch it at some points, but it seems to me that one would not be able to get readily the measure of the fluctuation, for which we must get the extremes, whereby we may get a correct idea of the range of variation; which is something that one often wants to know in making dynamometric tests.

I would like to know whether the author noticed any phenomena in the springs akin to hysteresis. I have sometimes observed that springs do not come back at once to their original form when the tension is released; they seem to experience a kind of hysteresis effect. They eventually get back but it may require considerable time. Of course the nearer the elastic limit is reached the worse that effect would be. Still I think it is noticeable in certain cases even when the strains applied to the spring are much below the elastic limit.

I would also like information regarding the range within which a particular outfit can be used; that is to say, how many springs would one require in a dynamometric outfit which was intended to cover a range of from one to forty or fifty horse power. With the Van Winkle dynamometer it is found necessary to transmit the power at different speeds in order to increase the range. The instrument is not applicable to many cases for which this one is applicable, for that very reason. In this case since we can couple the driving and the driven machines together it seems to me there might be a very wide range of power under great variation of speed.

PROF. GOLDSBOROUGH:—As Mr. Mailloux's remarks have been directed especially to me, I think I can say, as far as the matter of the dash-pot, for instance, is concerned, that in using the instrument we have found very little difficulty, indeed, from vibration.

I have also used a very successful dynamometer brought out by Professor Flather in which the amount of torque is measured by a series of pistons. These pistons operate in little cups or cylinders which are arranged on the rim of a wheel. For instance, if this represents one of the spokes of the wheel (making diagram

on the board) there would be a little cylinder attached here on a pin projecting out in this direction which the piston would fit, and transmit a pressure through suitable connecting means out to a gauge at the end of the shaft. This is a very good form of dynamometer. It is one that can be very successfully used in making tests on all sorts of machine tools, in connection with lathes, etc., where there are rapidly fluctuating loads, and it gives a perfect record where a proper speed counter is used, and where a recording drum is used for recording the torque. It enables one also to determine at any moment the torque which is developed. These instruments are usually of the belted type and have relatively quite a wide range of usefulness.

As far as I know our instrument is most accurate for measuring power and determining torque. The Van Winkle instrument I personally do not like, for the same reason that I object to the Flather dynamometer, in view of the fact that they are somewhat complicated. In getting out our instrument I wanted particularly, if I could, to devise a dynamometer which could be used at all times by the students without any danger of its getting out of order, and without their having to spend most of their time on the dynamometer instead of on the electrical apparatus. In cases where we have used a Prony brake, or other type of dynamometer, we have usually had more trouble with the dynamometer than with all the rest of the apparatus put together. In using the dynamometer which is discussed in the paper there is no trouble at all experienced in handling the instrument. The objection which has been raised, that it is impossible to get a reading of the instantaneous torque developed by the machine without first setting the brushes, is, I think a more or less pertinent criticism I have made drawings for a machine of the same type in which a resistance wire will be used: by having two collector rings arranged and a contact point pressing on the resistance wire, and then having a storage cell acting on a circuit through the wire and a Weston milli-voltmeter the variations in the angle of torque will be determined. In other words, when there is no torque there will be none of the resistance wire in the circuit, and consequently a minimum reading of the voltage by the milli-voltmeter. As the twist takes place in the shaft, the relative position of the two wheels is changed, and more and more resistance is introduced into the circuit. This necessarily cuts down the current and reduces the voltage reading on the milli-voltmeter. This arrangement, I think, can be successfully carried out to give at all times definite readings of torque, when the instrument has once been calibrated. On the other hand it introduces an additional adjustment in the apparatus itself and makes it just so much more complex; just so much more easily put out of order.

We have found it very easy, indeed, to get settings with the two contact brushes. We have found that by putting three Edi-

son-Lelande cells on the circuit and using a condenser of about one microfarad, in parallel with a telephone, the setting can be made very quickly. For instance, in running up the back of the induction motor torque curve, before the method of using the series generator was devised, an attempt was made to use a separately excited shunt-wound machine. A shunt-machine works all right until you get to a certain point on the curve, but after that it is impossible for you to hold the speed of the induction motor constant at any one point. For instance, in the case of the induction machine discussed, the speed-torque curve is, of course, that shown in Fig. 5 (illustrating.) Now the torque curve of the separately excited shunt generator is a straight line for any given resistance in its armature circuit. This arrangement holds the speed at constant values as long as the straight line speed-torque curves of the shunt generator cross the speed-torque curve of the induction motor at an abrupt angle. When, however, the speed-torque curve of the shunt generator becomes nearly parallel to that of the induction motor, owing to the reduction of the resistance in the shunt generator circuit, a condition of instability of speed is reached and both the speed and the torque of the induction motor will continuously rise. However, as the speed rises slowly, we have been able to follow up the torque reading—the man who reads the dynamometer calls off and the men reading the electrical instruments make their records at the same time. In this way we can work quite rapidly and get points right up the back of the speed-torque curve. If there were much difficulty in getting the setting with the dynamometer it would not be possible to follow along the curve. If you wish to have a great deal of stability in the instrument it is not necessary to use a dash-pot; it is only necessary to put in a heavier spring, and by using a stiff spring you can make the adjustment as stable as you wish. Of course, the finer the spring for any given power, the more difficulty you will have in getting your settings, because the angles through which the torsion takes place, as the load is changed, are very much greater.

In regard to the matter of hysteresis in connection with the spring, I have not made any determination whatever. The only determinations that we have made are these. Early in the afternoon, for instance, when an experiment is conducted which includes the use of the dynamometer, it is calibrated. The tests are then performed and immediately afterwards a second calibration is taken. The two dynamometer calibration curves when plotted fall absolutely on top of one another. When we calibrate a voltmeter just before and just after an experiment, or a wattmeter or an ammeter, we frequently find slight differences. The points in the two calibrations may scatter a little, or not fall exactly on one another. In the case of these springs we have found that they fall exactly in line; and so, in view of the fact that the error of the dynamometer must be inside of the error of

the electrical instruments, we have not thought it necessary to pay any special attention to hysteresis.

In regard to the number of springs; our instrument has a range up to 25 H. P. and for that range we have five springs, the smallest of which is two-tenths of an inch in diameter and the largest is about seven-tenths of an inch in diameter. With these springs we have a range which covers all machines from two H. P. up to 25 H. P. A very good efficiency curve can be obtained with an angle of only 90° total deflection at full load. You can then go from zero to full load and get very exact readings. If you put lighter springs in, necessarily your results are more accurate because you get a finer adjustment in the scale. I would say, though, for an instrument of this size you need at least five springs. If I were going to build another instrument, for larger powers, I would make it for use between 25 and 100 H. P.

I have found that this dynamometer method can be used by putting two machines in line and simply connecting a spring to the shafts of the machines, thereby removing the necessity of having an extra piece of apparatus. For instance, we have two railway motors in the laboratory; they are lined up and a spring connects the two shafts. The spring in this case acts both as a flexible connection between the machines and also as a dynamometer. A spring costs only about 60 cents, so that the spring is the smallest item of expense.

PROF. A. J. ROWLAND:—There is just one thing that occurred to me in connection with Prof. Goldsborough's paper, a point in design which makes the dynamometer especially commendable. It is not particularly with reference to the dynamometer either, but in connection with the means of recording the results. I refer to the use of a contact-maker. Anybody who has done anything with contact-makers knows how elusive they are; how small, trifling things, that are so subordinate that, though they seem as if they could count for nothing, throw one's results all out. Now in this case we do not look for silence as usual in such devices, but just the reverse. It is easy enough to get a contact-maker to operate so you can hear a tick in the receiver; it is difficult to get a contact-maker to work so that one procures silence. Perhaps it is obvious and so unnecessary to say, but certainly if a contact-maker is to be used, this means of reading, when the click of the telephone is made the guide for settings of the scale, is the only method which could be applied. There is always moving machinery to add to the noise in the receiver. Altogether the instrument as devised must be one which is easy to work with, and a dynamometer by which one ought to get very nice results.

PROF. GOLDSBOROUGH:—As far as the action of the telephone is concerned: in using the machine, my assistant first reported to me that he had no special difficulty in obtaining readings, but thought probably the width of the contact had some effect; so I took some trouble to find out just what the range of

accuracy is. In our machine the brush probably has a width of $\frac{1}{32}$ of an inch and a contact point width of $\frac{1}{32}$ of an inch. Now if you have one brush in a fixed position and move the other, you can move it along until you begin to hear a click. Move it a trifle further and the click becomes more pronounced until you get a maximum amount of sound. Proceeding still further the sound will diminish. By taking readings very carefully I have found that in ten readings we could every time bring the pilot brush right back to the same point. If you want to catch just a faint noise, you can get that adjustment. If you want to get the maximum amount of sound you can get that adjustment. Or if you want to carry it too far ahead and bring it back to a faint sounding position you can get that adjustment. So we have found that between zero sound on one side and zero sound on the other side, there is a limit of less than one-half of one degree in the scale reading where the spring is adjusted to give 180° deflection at full load. Half a degree in this case represents a very small error. By careful work, of course, you can make it much smaller. I do not know how the instrument would work if you were using it on very fluctuating loads. I do not know that it would be a success. It was not designed for that. It was designed to use with electrical machinery, where we can maintain our load with absolute constancy, you may say, for almost any length of time; and for that purpose it works nicely. What its value would be in testing lathes or machine tools of various kinds, in which the fluctuations are very rapid, I do not know; but for the use of the electrician and for rapid testing in either commercial or college laboratories, it has so far worked out very nicely, indeed.

MR. MAILLOUX:—I do not quite agree with Prof. Goldsborough as to the limitation of this instrument. I think it is really suited for many more purposes than he thinks, provided it has means of giving an indication of the deflection. I think that is really all it needs. It is free from the series of errors due to speed which are incident to the Van Winkle dynamometer. The only thing that it lacks is a means of giving an indication of those fluctuations, because if there are errors due to resonance, they can be measured, determined and accounted for and allowed for. I think it is possible to apply a device that will give scale indications.

I think really this is a very interesting apparatus, and one which has a far greater range of usefulness than Prof. Goldsborough claims for it.

THE PRESIDENT:—We will proceed with the next paper on "A Percentage Bridge," by Mr. Herschel C. Parker, of Columbia University.

[See p. 229, April issue.]

Discussion.

The President:—There already exist many methods of measuring resistances, but there are none too many, as most of us have found frequently, to our sorrow, that often the very resistance we want to measure cannot be measured as well as we would like, by the methods that are known to us. The present method points out the importance of measuring by percentages, and I think that principal ought to be recognized more than it is, because in making such calibrations it is not the absolute values of the errors that we are after, but the percentage value, and a method of finding this directly cannot fail to be of interest. The paper is open for discussion.

Prof. Goldsborough:—I have been very much interested indeed in reading this paper, and in listening to its presentation to-day. I very gladly welcome at all times anything that tends to reduce labor in calibrating instruments of any kind—anything that tends to greater simplicity. The greater the simplicity of the method the greater are the chances of ultimate accuracy in our results. This method commends itself, especially in view of the fact that it is a zero method, and we all know the value of zero methods. A zero method, in which a galvanometer is used may be said to be analogous to a contact method in which we adjust for maximum noise instead of trying to observe a point of silence. It gives us a direct indication that we have reached the desired result. Very frequently it is a very difficult matter to make a galvanometer which is sensitively adjusted, operate satisfactorily, unless we go to a great deal of trouble. At our own University we find that often the street railway currents affect our apparatus, when the street car line is not closer at any point than a quarter of a mile; and I have no doubt that in laboratories in cities which are less favorably located, experimenters experience much difficulty in getting their galvanometers to behave properly. Under these conditions a zero method is all the more valuable, as it eliminates the necessity of taking a reading of a given deflection. We have found instances in the case of very delicate readings that we have been making recently at the Purdue University, that it has been necessary for the experimenters to do all their work between 1 o'clock at night and early morning before the street car lines start up. We reach a time only then when our instruments can be very delicately adjusted.

I very gladly welcome any method which tends to simplicity and greater accuracy with less wear and tear on the human frame; so I think those of us who are in charge of laboratories will welcome this particular device for standardizing our resistance coils as something to be highly commended.

The President:—Is there any further discussion. If not, the Secretary has some announcements to make.

The Secretary:—To-day's session ends with the paper just read. I take pleasure in announcing that the Local Committee

has arranged for a "Smoker," which by the courtesy of the Manufacturers' Club will be held at its rooms, No. 1405 Walnut Street.

Mr. Charles A. Bragg, Chairman of the Local Committee then read letters of invitation to the INSTITUTE to visit Cramp's Shipyard, the Baldwin Locomotive Works, and the Franklin Institute.

The meeting then adjourned to Thursday, May 17th.

BOOKS RECEIVED BY THE INSTITUTE.

DYNAMO ELECTRIC MACHINERY; ITS DESIGN, CONSTRUCTION AND OPERATION. By Samuel Sheldon, A.M. Ph.D., Professor of Physics and Electrical Engineering, Polytechnic Institute of Brooklyn. Assisted by Hobart Mason, B.S. D. Van Nostrand Co., New York. 280 pp. 202 cuts. Price, $2.50.

This book is intended to be used, primarily, in connection with introduction on courses of electrical engineering, in institutions for technical education. It is laid out on the lines of the lectures and instructions, as given in the Polytechnic Institute of Brooklyn. It is intended equally as much for the general reader, who is seriously looking for information concerning dynamo electrical machinery of the type discussed, as well as a book of reference for engineers.

CONTENTS:—Electrical Laws and Facts; Magnetic Laws and Facts; Armatures; Field Magnets; Operation of Armatures; Efficiency of Operation; Constant Potential Dynamos; Constant Current Dynamos; Motors; Series Motors; Dynamotors; Motor-Generators, and Boosters; Management of Machines; The Design of Machines; Tests.

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Contents of Vol. XVI, 1899.

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